

LAKE HAVASU NATIVE FISH MANAGEMENT PROGRAM

1996 and 1997 PROJECT REPORT

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¹ Stand alone appendix.

² Stand alone appendix.

DISCLAIMER

The findings, opinions, and recommendations in this report are those of the investigators who have received partial funding from the Arizona Game and Fish Department Heritage Fund. The findings, opinions, and recommendations do not necessarily reflect those of the Arizona Game and Fish Commission or the Department, or necessarily represent official Department policy or management practice. For further information, please contact the Arizona Game and Fish Department.

INTRODUCTION

Razorback suckers *Xyrauchen texanus* and bonytail chub *Gila elegans* were once widespread throughout the Colorado River system. In the past 100 years, the ranges and populations of these native species have declined (Jordan and Everman 1896, Miller 1961, Minckley and Deacon 1968, Johnson and Rinne 1982, Minckley 1983). In the Lower Basin razorback suckers have been virtually extirpated from riverine environments and most impoundments, however, a relatively large population still exists in Lake Mohave, AZ-NV (Minckley et al. 1991). The bonytail is presently represented in the Lower Basin by a low number of senile fish in Lake Mohave and possibly other Lower Basin reservoirs (USFWS 1990). Due to the combined effects of habitat loss, proliferation of introduced fishes and other man-induced disturbances (Miller 1961, Minckley 1973, Carson and Muth 1989) these fishes are threatened with extinction and are now listed as endangered under the Federal Endangered Species Act of 1973.

The precarious status of the razorback sucker and bonytail chub dictates that immediate and positive efforts be initiated to prevent their extirpation in the lower Colorado River. The Lake Havasu Native Fish Management Plan (Bureau of Land Management 1992) offers a unique opportunity for the cooperative recovery of endangered species of native fish.

The objective of the Lake Havasu Native Fish Program (LHNFP) is to release 30,000 razorback suckers ($\geq 250\text{mm}$) and 30,000 bonytail chub ($\geq 250\text{mm}$) into Lake Havasu AZ-CA, by the year 2003. The augmentation of these populations began in the summer of 1993. From 1993 to 1994 the program utilized small isolated habitats adjacent to the lower Colorado River to growout juvenile razorback suckers and bonytail chub prior to release into Lake Havasu. Two growout coves were used during the 1994 production period. The program was expanded to 12 growout facilities in 1995. In 1996 each facilities production capability was closely examined resulting in discontinuing the use of No Entry Cove. In 1997 Helicopter Cove, Pittsburg Point Cove, Twin Cove North, and Twin Cove South were abandoned leaving seven rearing facilities.

Sites other than those utilized along the lower Colorado River have provided additional razorback suckers and bonytail chub fish for our program. Arizona Game and Fish Department (AGFD) has committed to rear for our program 30,000 large razorback suckers at their Bubbling Ponds rearing facility near Cottonwood, AZ. Other notable contributions include razorback suckers from U.S. Fish and Wildlife Service (FWS) Southwestern Technology Center (SWTC) and bonytail chub from Palm Lake at the Hasayampa Nature Conservancy Preserve near Wickenburg, AZ.

Over four production periods³ (1994-1997) a total of 27,293 juvenile razorback suckers and 227,206 juvenile bonytail chub were stocked into LHNFP growout facilities. Since 1993, survival from these ponds of both species to a releasable length has been poor. From 1993 through 1997 overall growout facility survival has been estimated at 0.005% for razorback suckers and 0.001% for bonytail chub. The total number of fish released into Lake Havasu from LHNFP growout facilities, Bubbling Ponds, SWTC, and Palm Lake from 1994 through 1997 is 2,360 razorback suckers and 303 bonytail chub.

PROJECT AREA

During the 1996 production season, Bulkhead Cove, Helicopter Cove, Office Cove, Pittsburg Point Cove, Twin Cove North, and Twin Cove South on Lake Havasu, and Pond 1, Pond 12, Pond 18I, and Pond 18U along the Colorado River below Parker Dam on the Emerald Canyon Golf Course (ECGC) in Arizona along the Parker Strip (Figure 1, Appendix A) were used to rear juvenile razorback suckers and bonytail chub. The High Levee Pond, AZ-CA (Figure 2, Appendix A) at the Cibola National Wildlife Refuge (CNWR) was also utilized to growout bonytail chub in 1996. In 1997 the number of facilities in use dropped to two on Lake Havasu and included Bulkhead Cove, CA and Office Cove, AZ. Use of the four ponds at the ECGC as well as the High Levee Pond at the CNWR was continued. Legal descriptions of

³ Approximately a one year period starting at stocking, typically in the fall.

the growout coves are provided in Table 1.

TABLE 1. Legal Descriptions of growout facilities used during the 1996 and 1997 production periods.

Growout Facility	Legal Description
Lake Havasu:	
Bulkhead Cove	T. 3 N., R. 27 E., Sec 33 NESE, SBM, CA
Helicopter Cove	T. 13 N., R. 20 W., Sec 17 SESE, GSRM, AZ
Office Cove	T. 11N., R. 18 W., Sec 14 SWSE, GSRM, AZ
Pittsburg Point Cove	T. 13 N., R. 20 W., Sec 20 NWNE, GSRM, AZ
Twin Cove North	T. 6 N., R. 24 E., Sec 36 NESE, SBM, CA
Twin Cove South	T. 6 N., R. 24 E., Sec 36 NESE, SBM, CA
Emerald Canyon Golf Course:	
Pond 1	T. 10 N., R. 19 W., Sec 12 NWNE, GSRM, AZ
Pond 12	T. 10 N., R. 19 W., Sec 12 SWSW, GSRM, AZ
Pond 18 Lower	T. 10 N., R. 19 W., Sec 12 NESW, GSRM, AZ
Pond 18 Upper	T. 10 N., R. 19 W., Sec 12 NESW, GSRM, AZ
Cibola National Wildlife Refuge:	
High Levee Pond	T. 1 S., R. 24 W., Sec 14 SWSE, GSRM, AZ

MATERIALS and METHODS

Barrier Nets

Due to the lack of suitable, naturally occurring isolated habitats available in the project area, barrier nets were used in two coves. These nets were individually designed and constructed to conform to site specific pond dimensions. Nets were made of quarter inch delta mesh dipped in plasti-coat. Suspension was provided by oval barrier floats, spaced four feet apart, and held in place using quarter inch aircraft cable. At Twin Coves metal "T" posts, driven into the ground at opposite ends of the net, provided anchoring points for the cable. The tops of all nets were wrapped over the barrier float line to elevate it about 30 cm above

the water surface to minimize fish escapement or entry over the net. Sand bags, installed by SCUBA divers, were used to anchor the bottom of the net. Spacing of sand bags, determined by substrate type and topography, was typically two to four feet. To hold the sand bags in place, the bottom of the net was wrapped over the bags and tied to a seam at the back of the net with plastic "zip-ties". Over time sedimentation helped anchor the nets.

Fish Capture

Considerable effort was made to capture bonytail chub and razorback suckers from all facilities to monitor growth and survival and to control piscivorous fish in facilities with barrier nets. A wide variety of gear was used and included trammel nets (length 91.4 m, width 1.82m, inner mesh 2.54 cm, outer mesh 30.5 cm and length 30.48 m width 1.82 m, inner mesh 1.27 cm, outer mesh 15.24 cm), cylindrical wire minnow traps (length 91.44 cm, dia. 22.86 cm, mesh 0.64 cm, throat 2.54 cm; length 91.44 cm, dia. 30.48 cm, mesh 0.64 cm, throat 5.08 cm; and length 121.92 cm, dia. 91.44 cm, mesh 1.27 cm, throat 7.62 cm), and hoop-nets (length 1.83 m, dia. 0.91 m, mesh 0.64 cm, throat 10.16 cm). Trammel nets were set at night and ran a minimum of every two hours. Traps were set and ran during the day (soak time one to two days).

To monitor and control large non-target fish, primarily piscivorous fish, that had immigrated into Twin Cove North and Twin Cove South, 6.35 cm square mesh gill nets (length 60.96 m, width 1.83 m) were used extensively in these coves.

A bag seine (length 91.44 m, width 3.05 m, bag 3.05 X 3.05 m, mesh 1.27 cm) was used to sample ponds at the Emerald Canyon Golf Course. The seine is large enough to completely cover each pond in one haul. One to three hauls are made at each pond per effort-day.

Fyke nets (length 6.1 m, width 1.8 m, height 1.8 m, mesh 0.64 cm) with two wings (length 15.3 m, width

1.83 m, mesh 0.64 cm) were set in Twin Cove North and Twin Cove South (one in each cove) and ran continuously for 3.5 months. The effort was primarily to control piscivorous fish species.

Total length (TL) in millimeters and weight in grams (g) were recorded for each razorback sucker and bonytail chub collected and for most other species captured. Numbers and mass weights of non-native species were recorded. Individual total lengths and weights of non-natives were occasionally taken. All bonytail chub and razorback suckers from growout ponds along the lower Colorado River and released into Lake Havasu were tagged with passive intragrated transponders (PIT tags). Razorback suckers released into Lake Havasu reared at Bubbling Ponds State Fish Hatchery were tagged with coded wire tags.

Water Quality

Water quality stations were established at the location of the maximum depth of each pond. Frequency of site visits varied but each facility was monitored usually no less than once per month. Samples were collected between 0900 and 1500 hours. Measurements of depth (m), water temperature (deg. C), dissolved oxygen (DO, mg/L), specific conductivity (mS/cm), total dissolved solids (g/L), and pH were made with a Hydrolab Corporation H20 submersible data transmitter, with direct readout. These variables were measured every one-half meter from surface to bottom. Secchi depth visibility was determined with a standard 20 cm secchi disk. Total alkalinity (mg/L) was measured at 0.5 meters using a Hach Cematic Company, Model FF-1, Fish Farmer Water Quality Test Kit.

Aquatic Macroinvertebrates and Zooplankton

Aquatic macroinvertebrate and zooplankton collection and analysis methods are discussed in detail in reports completed by the U.S.D.I. Bureau of Land Management Aquatic Ecosystem Laboratory (Appendices B,C,D, and E).

Statistics

The computer program SYSTAT Version 7.0 (SPSS 1997) was used to compute monthly statistics of all water quality parameters reported.

PREVIOUS GROWOUT COVE PRODUCTION ACCOMPLISHMENTS

1994 Production Overview

Field work on the Lake Havasu Native Fish Management Plan began in 1993 with the stocking of 6,204 razorback suckers (*Xyrauchen texanus*) and 22,240 bonytail chub into Pittsburg Point Cove and Office Cove, both adjacent to Lake Havasu. From these two ponds, Palm Lake at the Hasayampa Nature Conservancy Preserve, and the SWTC, 859 razorback suckers were released into Lake Havasu during the 1994 production period. Also in 1994, 60 bonytail chub obtained from Palm Lake were released into Lake Havasu.

1995 Production Overview

During the 1995 production season a total of 12,518 juvenile razorback suckers, 163,023 juvenile bonytail chub, and 250 larval bonytail chub were stocked into twelve growout ponds. From these facilities, nineteen large bonytail chub were captured and released into Lake Havasu. No razorback suckers were released into Lake Havasu in 1995. A unknown number of the razorback suckers and bonytail chub released into Lake Havasu in 1996 were most likely fish stocked during the 1995 production period. Since stocked fish are not marked it is difficult to distinguish year classes. Multiple year classes occur in several ponds which make annual survival estimates difficult to accurately determine.

1996 PRODUCTION PERIOD

Stocking

During the 1996 production season 16,855 juvenile razorback suckers and 19,620 juvenile bonytail chub were stocked into eleven growout facilities (Figure 1). Juvenile bonytail chub were provided by the SWTC as juveniles and were stocked into Helicopter Cove, Pittsburg Point Cove, and Office Cove (Table 2). Razorback sucker juveniles were obtained from SWTC and from Lake Mohave paired matings and stocked into Bulkhead Cove, Helicopter Cove, Pittsburg Point Cove, Twin Cove North, and Twin Cove South on Lake Havasu and Pond 1, Pond 12, Pond 18 Lower, and Pond 18 Upper at the Emerald Canyon Golf Course (Table 2). All fish stocked were of the 1995 year class. Additional fish for growout were carryover bonytail chub and razorback suckers (Table 2) stocked in 1994 and 1995 and bonytail that successfully spawned in Pond 1 at the Emerald Canyon Golf Course in 1995.

Fish Transfers

To reduce fish density and/or salvage fish from certain mortality due to low summertime DO levels and high water temperatures, bonytail chub and razorback suckers in five growout ponds were captured and transferred to Office Cove (Table 3). Office Cove has several positive attributes that make it a good location for releasing salvaged fish including its large size (2.5 surface acres), accessibility, and security from predator fish as it is separated from Lake Havasu by a man-made berm. Also, water quality during the summer, improved by the installation of a passive, wind powered circulator, is not known to cause substantial fish mortality.

Renovation

In September 1996, Bulkhead Cove was renovated using 10 gallons of 5% liquid rotenone to remove a persistent population of yellow bullheads *Ameiurus natalis*. Forty one were recovered and ranged in length from 97.0 mm to 242.0 mm (Appendix F). Ninety six percent were young of the year (YOY).

Pittsburg Point Cove was rotenoned in October 1996 to remove competing and predaceous fish species. Common Carp *Cyprinus carpio* (n=116), Goldfish *Carassius auratus* (n=259), and yellow bullhead (n=79) were collected (Appendix F).

Table 2. Stocking data for juvenile bonytail chub (BTC) and razorback suckers (RZBK) stocked into Lake Havasu growout facilities in the 1996 production period. Species marked with an asterisk (*) have multiple year classes.

Growout Facility	Surface Area (Acres)	Species	Total Number Stocked
Lake Havasu:			
Bulkhead Cove	0.21	BTC	0
		RZBK	1083
Office Cove	2.40	BTC	11000
		RZBK*	0
Pittsburgh Point Cove	1.28	BTC	350
		RZBK	300
Helicopter Cove	0.14	BTC	270
		RZBK	300
Twin Cove North	1.50	BTC	0
		RZBK	3259
Twin Cove South	1.50	BTC	0
		RZBK	3545
Emerald Canyon Golf Course:			
Pond 1	0.90	BTC*	0
		RZBK	1465
Pond 12	1.60	BTC	0
		RZBK	4423
Pond 18 Upper	0.39	BTC	0
		RZBK	1290
Pond 18 Lower	1.08	BTC	0
		RZBK	1290
Cibola National Wildlife Refuge:			
High Levee Pond ¹	4.90	BTC*	8000
Totals	15.9	BTC	19,620
		RZBK	16,855

1 Razorback suckers growout in the High Levee Pond were not stocked into Lake Havasu.

Table 3. Transfers of bonytail chub and razorback suckers into Office Cove during the 1996 production period. Asterisk (*) indicates respective species was not stocked in 1996.

Growout Facility	Species	Total Number Removed	Number Removed to Number of Fish Stocked (%)
Lake Havasu:			
Pittsburgh Point Cove	BTC	25	7.1
	RZBK	35	11.7
Helicopter Cove	BTC	17	6.3
	RZBK	11	3.7
Emerald Canyon Golf Course:			
Pond 1	BTC ¹	379	*
	RZBK	144	9.8
Pond 12	BTC ²	129	*
	RZBK	106	2.4
Pond 18 Upper	BTC ³	13	*
	RZBK	125	9.7
Totals	BTC	563	--
	RZBK	421	--

1 Bonytail chub were not stocked into Pond 1 in 1996. All bonytail captured were from successful spawning in the spring of 1995. Some carry over from the October 1994 stocking is possible.

2 Bonytail chub were not stocked into Pond 12 in 1996. Those captured were primarily carry over from stocking in October 1994 with possible spawning occurring in 1995.

3 Bonytail chub were not stocked into Pond 18 Upper in 1996. Those captured were carry over from stocking in October 1994. No evidence of spawning in this pond during 1995.

Growout Pond Survival and Releases into Lake Havasu

In 1996, a total of 163 bonytail chub and 146 razorback suckers reared in growout ponds were released into Lake Havasu (Table 4, Appendix G). These fish were primarily 1996 age group fish stocked in the fall of 1996, however, some were carry-over fish stocked in 1995 (1995 age group) and a few possibly came from 1994 stockings. Multiple year classes may skew survival estimates (Table 4).

Table 4. Survival estimates for razorback suckers and bonytail chub grown-out in Lake Havasu Native Fish Program facilities and released into Lake Havasu during the 1996 production period. Single asterisk (*) indicates multiple year classes. Pound sign (#) indicates species being reared in 1996 that will carryover into 1997. Percent survival marked with an exclamation point (!) indicate estimates we are unable to calculate.

Growout Facility	Species	Number Stocked	Number Released	Percent Survival
Lake Havasu:				
Bulkhead Cove	BTC*	0	2	!
	RZBK	1,083	9	0.8
Office Cove	BTC*	11,000	14	0.1
	RZBK**	0	8	!
Pittsburgh Point Cove ¹	BTC	350	3	0.9
	RZBK	300	0	0
Helicopter Cove ¹	BTC	270	2	0.7
	RZBK	300	0	0
Twin Cove North	BTC	0	0	
	RZBK	3,259	0	0
Twin Cove South	BTC	0	0	
	RZBK	3,545	0	0
Emerald Canyon Golf Course:				
Pond 1 ¹	BTC**	0	4	!
	RZBK#	1,465	53	3.6
Pond 12 ¹	BTC**	0	50	!
	RZBK#	4,423	42	0.9
Pond 18 Upper	BTC*	0	2	!
	RZBK	1,290	0	0
Pond 18 Lower	BTC*	0	1	!
	RZBK#	1,290	0	0
Cibola National Wildlife Refuge:				
High Levee Pond	BTC**	8,000	85	1.1
Totals	BTC	19,620	163	0.8
	RZBK	16,855	146	0.9

¹ Effort was made in these ponds to salvage fish in spring and early summer to avoid low dissolved oxygen levels. All fish salvaged were placed into Office Cove.

Essentially the entire razorback sucker and bonytail population reared in Bulkhead Cove in 1996 was lost in June when the pond became anoxic. In May we were however, able to capture two bonytail and nine razorbacks and release them into Lake Havasu.

The transfer of fish into Office Cove, along with the presence of multiple year classes, has made estimating survival accurately difficult in that pond. These fish were not marked and are therefore unable to recognize their contribution to the number of fish released into Lake Havasu. Nevertheless, 14 bonytails and 8 razorback suckers were released into Lake Havasu from Office Cove.

Very few fish were released into Lake Havasu from Pittsburg Point Cove or Helicopter Cove. As these ponds become anoxic during the summer we salvaged as many as possible (Table 3) in the spring and relocated them to Office Cove to complete growout.

The barrier nets at Twin Coves were ineffective in preventing movement of fish in or out of the facility. A small number of short tears in both nets probably allowed fish to move in and out of the cove. Also, rotenone treatments in 1995 may not have been complete. For whatever reason, the predator load in these coves was very high after stocking. Several capture efforts after stocking resulted in one razorback being caught in January 1996, two months after stocking.

The four ponds at the Emerald Canyon Golf Course are designed such that they can be effectively seined and most, if not all, fish can be removed. Survival estimates are therefore fairly accurate. Summertime water quality conditions are suitable, although not optimal, for both bonytail and razorback suckers which obviously increases survival. No bonytail were stocked into these ponds in 1996 but we were able to capture 57 bonytail that originated from other stockings and/or spawning and released them into Lake Havasu. We were unable to conduct any harvest effort in the fall when the majority of the bonytail and razorbacks would have been long enough to be released.

Due to the travel distance to the High Levee Pond only seven capture efforts were made during the 1996 production period. Many stocked fish remain in this pond and both razorbacks and bonytail are known to have spawned. Although both bonytail and razorbacks are reared in this pond, only bonytails are released into Lake Havasu. Multiple year classes and spawning obscure bonytail survival estimates. During the 1996 production period 85 bonytail were released into Lake Havasu.

The parasitic copepod *Lernaea carassii* occurs in all growout ponds. The copepod is not known to be exceptionally abundant but infestations may be great enough to slow growth in some fish and may cause mortality. Recently expired fish are rarely observed in growout ponds and the few collected have not been heavily infested. Live fish have from none to 10 *Lernaea* externally during the summer. The effect of *Lernaea* on the survival of native fish in our growout ponds is largely unknown. Other fish diseases may also effect fish survival but to what extent is unknown.

Water Quality

Water quality was monitored in all growout ponds throughout the year (Appendix H). Not surprisingly, low dissolved oxygen levels and high water temperatures during the summer were found to greatly affect fish survival in Pittsburg Point Cove, Helicopter Cove, and Bulkhead Cove (all bermed coves). These conditions resulted in essentially the loss of all fish in Bulkhead Cove. Summer water quality conditions are also thought to slow or stop fish growth and to some extent lower fish survival in Office Cove, High Levee Pond, and all four Emerald Canyon Golf Course Ponds.

Growth

Growth of razorback suckers and bonytail chub was good in all ponds from stocking in the fall until May or June when adverse water quality conditions inhibit feeding. Food resources also become scarce during the summer months in most ponds resulting in further growth reduction (Table 5, Appendices B,C,D, and E). Recruitment of age-0 fish into the population via spawning and/or stocking made interpretation of length data difficult in some ponds. Also, cropping fish greater than 250mm TL made growth

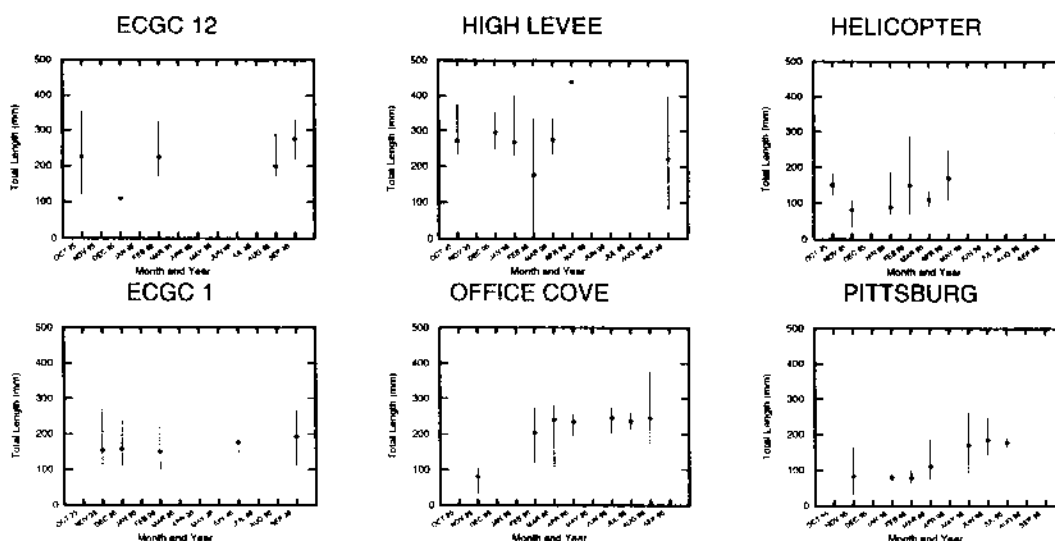
Table 5. Seasonal aquatic macroinvertebrate biomass (g/m²) and zooplankton abundance (number/liter) in Lake Havasu Native Fish Program growout ponds during 1994 and 1995. ECGC = Emerald Canyon Golf Course.

Growout Pond	Fall	Winter	Spring	Summer
Macroinvertebrate Biomass				
Bulkhead Cove	1.2328	3.8112	0.4949	0.1154
Helicopter Cove		1.2492	0.4931	0.0034
No Entry Cove		0.2892	0.1241	0.0276
Office Cove	0.2142	0.7957	0.7569	0.5788
Pittsburg Point Cove	0.0	0.0154	1.3483	0.0026
Twin Cove North		2.40	0.8897	0.0692
Twin Cove South		3.3662	0.7690	0.4212
ECGC-Pond 1		1.2748	0.9845	0.1793
ECGC-Pond 12		0.2205	0.4690	0.0897
ECGC-Pond 18 Lower		0.1844	0.3069	0.0030
ECGC-Pond 18 Upper		2.6939	1.2534	0.6879
Zooplankton Abundance				
Bulkhead Cove	0.04	13.05	12.72	0.10
Helicopter Cove	5.20	0.08	41.49	0.05
No Entry Cove		1.33	0.35	
Office Cove	9.52	10.55	4.25	0.02
Pittsburg Point Cove	0.01	12.94	182.25	<0.01
Twin Cove North	10.67	0.12	0.69	
Twin Cove South	0.82	0.97	0.74	
ECGC-Pond 1	14.86	99.94	112.54	1.79
ECGC-Pond 12	0.05	3.53	23.61	1.44
ECGC-Pond 18 Lower	0.07	2.50	2.38	0.18
ECGC-Pond 18 Upper	0.44	0.43	6.91	0.19

appear to slow. Growth for both species is typically greatest in the spring and early summer when water temperatures are between 20 and 27 degrees Celsius. Below and above this temperature range, growth slows considerably. The optimal temperature range appears to be 22 to 25 degrees Celsius.

Bonytail chub growth (Figure 3, Appendix I) is best analyzed using data collected from Helicopter and Pittsburg Point Coves. These two ponds become anoxic during the summer therefore, there are no multiple ages to obscure the analysis and only one age group is represented in the data.

Figure 3. Monthly growth of bonytail chub in selected Lake Havasu Native Fish Management Program growout facilities during the 1996 production period. Vertical bars represent maximum and minimum total lengths. Circles are the means of the length data.

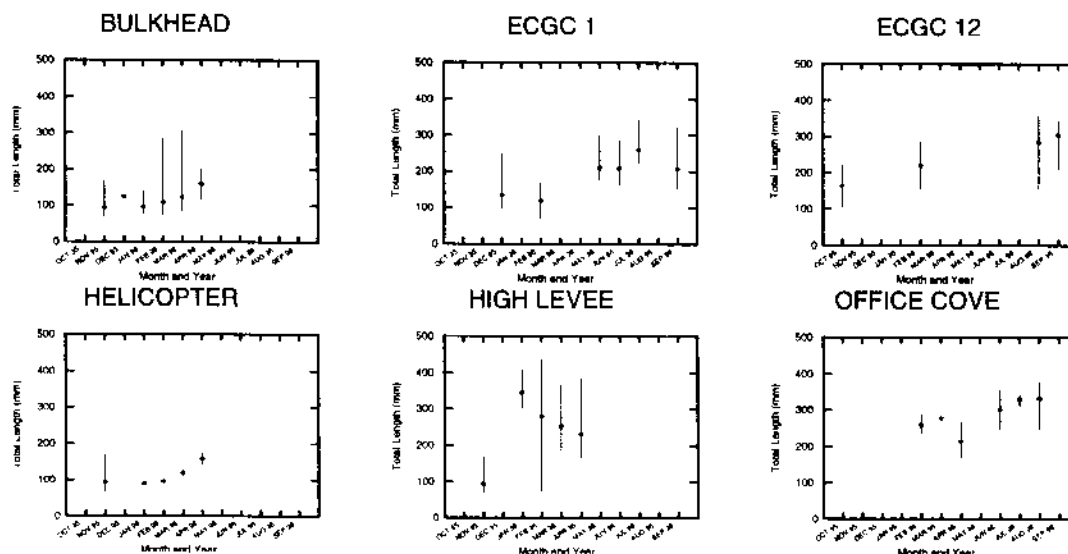


One bonytail chub in Helicopter Cove (Figure 3) attained our target length of 250 mm TL in February only three months after stocking in November. The population grew an average 4.7 mm/mo from stocking in November 1995 to January 1996 and increased slightly to 9.7 mm/mo from January to March. Substantial growth of 61.0 mm/mo occurred from March to April. In April all fish were removed by seining.

Pittsburg Point Cove bonytails (Figure 3) showed no growth from stocking in November to February. From February to March however, they grew an average of 32.5 mm. Growth almost doubled in April when they grew 58.8 mm. From April to June they slowed to 7.1 mm/mo, probably as a result of increasing water temperatures. No growth was seen in June and July as a result of very low DO concentrations and water temperatures exceeding 28 degrees Celsius. Food resources (zooplankton and macroinvertebrates) are minimal in Pittsburg Point Cove during the warmer months (Table 5, Appendices B and D) and to a certain extent accounts for the slower growth seen in June and July. In May a strong effort was made to remove all fish from this facility to prevent excessive mortality during the summer.

As with bonytail chub growth, razorback sucker growth (Figure 4, Appendix I) is best analyzed using the data containing only one age group. Ponds meeting this criteria with sufficient data for analysis include Bulkhead Cove and Helicopter Cove (Figure 4). Bulkhead Cove showed the highest growth with fish being released only three months after stocking at a mean TL of 92.4mm. To determine if supplemental feeding of all ponds was feasible, razorback suckers in Bulkhead Cove were stocked (5157 fish/acre) and hand fed a commercial diet every two or three days at a rate of 3% body weight per day. From stocking in November 1995 to January 1996 they grew 1.7 mm/mo; from January to February, 11.7 mm; February to March, 14.7 mm; and from March to April, 37.2 mm (Figure 4). Compared to razorback suckers on natural feed in Helicopter Cove, supplemental feeding appears to allow for higher stocking densities. In Helicopter Cove razorbacks and bonytails were stocked at a lower density (4071 fish/acre) than in Bulkhead Cove. Razorbacks in Helicopter Cove grew 0.9 mm/mo from November 1995 to February 1996, 23.6 mm from February to March, and 38.9 mm from March to April (Figure 4). Growth rates between these two ponds does not appear to be significantly different. However, a greater number of fish/acre can be reared in a pond receiving supplemental feeding. Given the low number of fish released into Lake Havasu in previous years and our need to produce large numbers of releasable length fish, supplemental feeding will be conducted at most ponds in 1997.

Figure 4. Monthly growth of razorback suckers in selected Lake Havasu Native Fish Management Program growout facilities during the 1996 production period. Vertical bars represent maximum and minimum total lengths. Circles are the means of the length data.



Based on personal observations, bonytail chub and razorback sucker growth in the three ponds analyzed is largely representative of growth in all our other ponds. Not surprisingly, growth tends to be slow from stocking in the fall through the winter when water temperatures are cool. As water temperatures increase growth substantially increases until summer when temperatures become high and growth slows.

Maximizing growth during the fall, winter, and spring with supplemental feeding would shorten the growing season and provide more releasable length fish before adverse summer conditions occur.

1997 PRODUCTION PERIOD

A total of seven growout facilities were used during the 1997 production period (Figures 1 and 2). Four facilities were discontinued for growing-out native fish in 1997. These included Pittsburgh Point Cove and Helicopter Cove due to anoxic conditions during the summer and Twin Coves North and South because of the inability of barrier nets to prevent movement of fish in and out of the coves.

A substantial number of the fish we will release into Lake Havasu in coming years will come from established aquaculture facilities. In 1997, AGFD began delivering large razorback suckers from Bubbling Ponds with 10,000 planned to be stocked into Lake Havasu in coming months. Razorback suckers are now being produced at the FWS Achii Hanyo rearing facility near Parker, AZ. Also in 1997, the LHNFP began negotiations with the Imperial Irrigation District (IID) to rear bonytail chub. This rearing opportunity will be lead by the California Department of Fish and Game. IID is receptive to rearing bonytail chub at the Nyland Warm Water Hatchery which they lease from the State of California. It will, however, be almost two years before Lake Havasu receives any large bonytails from Nyland.

Growout cove production enhancements in 1997 include the installation of solar powered automatic fish feeders at six of the seven facilities to increase growth rates. At Bulkhead Cove, summer water quality was historically poor. To alleviate this situation a one horse-power pump was installed to move higher quality water from Lake Havasu to the cove, a distance of about 200 feet. Also, an aerator was installed in Bulkhead Cove to assist in eliminating anoxic conditions.

Stocking

Razorback sucker juveniles were obtained from 1:1 paired matings of Lake Mohave fish and stocked into five ponds (Table 6). All fish stocked were of the 1996 year class. No bonytail chub were stocked in 1997. Carryover of fish stocked in 1996, 1995, and to a lesser extent 1994 occurred in the High Levee Pond, Office Cove, and Pond 1 at the Emerald Canyon Golf Course. Also, bonytail are known to have successfully spawned in ECGC Pond 1 in 1995 and Office Cove and the High Levee Pond in 1996.

Renovation

In the fall of 1997, Bulkhead Cove was treated with 10 gallons of 5% liquid rotenone to rid the pond of yellow bullhead that were not totally eradicated during the last treatment in 1996. A total of 1210 fish were recovered and included yellow bullhead (n=1195), channel catfish *Ictalurus punctatus* (n=1), green sunfish

Table 6. Stocking data for juvenile bonytail chub (BTC) and razorback suckers (RZBK) stocked into Lake Havasu growout facilities in the 1997 production period. Facilities with known carryover, either from previous stockings or natural recruitment, are marked with an asterisk (*).

Growout Facility	Surface Area (Acres)	Species	Total Number Stocked
Lake Havasu:			
Bulkhead Cove	0.21	BTC	0
		RZBK	744
Office Cove	2.40	BTC	0
		RZBK*	0
Emerald Canyon Golf Course:			
Pond 1	0.90	BTC*	0
		RZBK	800
Pond 12	1.60	BTC	0
		RZBK	1,243
Pond 18 Upper	0.39	BTC	0
		RZBK	547
Pond 18 Lower	1.08	BTC	0
		RZBK	1,106
Cibola National Wildlife Refuge:			
High Levee Pond ¹	4.90	BTC*	0
		BTC	0
		RZBK	4,440
Totals	11.48		

¹ Razorback suckers grown out in the High Levee Pond were not stocked into Lake Havasu.

Chaenobryttus cyanellus (n=3), threadfin shad *Dorosoma petenense* (n=1), and razorback sucker (n=10)(Appendix F). Four razorbacks were revived, PIT tagged, and released into the lake. The origin of the channel catfish, green sunfish, and threadfin shad is unclear, but they may have been illegally introduced.

Growout Pond Survival and Releases into Lake Havasu

In 1997 a total of 121 bonytail chub and 1,517 razorback suckers were released into Lake Havasu (Table 7, Appendix J). Razorback suckers released into Lake Havasu were primarily 1996 age group fish. However, some were carryover fish stocked in 1996 (1995 age group) and a few possibly came from 1994 stockings.

Survival at three of the four Emerald Canyon Golf Course Ponds, Bulkhead Cove, and Office Cove (Table 7) was enhanced with supplemental feeding. Mechanical aeration at Bulkhead Cove also increased production in that pond. From Bulkhead Cove, 290 razorback suckers (39% survival) were released into Lake Havasu. At Office Cove, 75 bonytail and 25 razorbacks were released. A total of three bonytails and 245 razorbacks (7% survival) were released from the Emerald Canyon Golf Course. From the High Levee Pond 43 bonytail were liberated into Lake Havasu. Annual survival estimates at Office Cove and the High Levee Pond are not computable due to the presence of multiple age classes of both species.

As during the 1996 production period, multiple year classes make it difficult to estimate survival (Table 7). Also, as we are unable to harvest all fish from Office Cove, Emerald Canyon Golf Course Ponds, and the High Levee Pond, some carryover into 1998 is expected to occur in these ponds (Table 7). Discontinuing the use of four ponds we were unable to effectively manage has increased overall survival and produced more releasable length fish. More time and attention is now being spent on each pond and results are directly proportional, e.g. improvements to summertime water quality at Bulkhead Cove provided 290 razorbacks in 1997.

On November 5, 1997, the first shipment of large razorback suckers (N=940) were received from Bubbling Ponds. The fish were released into Lake Havasu at Lake Havasu City. It is planned that by the end of the year Bubbling Ponds will release approximately 10,000 razorback suckers, 250mm TL or greater in length, into Lake Havasu.

Table 7. Survival estimates for razorback suckers and bonytail chub grown out in Lake Havasu Native Fish Program facilities and released into Lake Havasu during the 1997 production period. Single asterisk (*) indicates species in ponds in which carryover of fish stocked in 1996 or earlier occurred. Pound sign (#) indicates species being reared in 1996 that will carryover into 1997. Percent survival marked with an exclamation point (!) indicate estimates we are unable to calculate.

Growout Facility	Species	Number Stocked	Number Released	Percent Survival
Lake Havasu:				
Bulkhead Cove	BTC*	0	0	
	RZBK	744	290	39.0
Office Cove	BTC*	0	75	!
	RZBK**	0	25	!
Emerald Canyon Golf Course:				
Pond 1	BTC**	0	3	!
	RZBK*	800	138	17.3
Pond 12	BTC**	0	0	
	RZBK*	1,243	83	6.7
Pond 18 Upper	BTC*	0	0	
	RZBK	547	0	0
Pond 18 Lower	BTC*	0	0	
	RZBK*	1,106	24	2.3
Cibola National Wildlife Refuge:				
High Levee Pond	BTC**	0	43	!
Totals	BTC	0	121	!
	RZBK	4,440	577	13.0

Water Quality

As in 1996, water quality was monitored in all growout ponds throughout 1997 (Appendix H). Extremely low DO levels and high water temperatures during the summer were not found to greatly affect fish survival in any of the seven facilities used in 1997. Conditions may have been poor enough during the summer to restrict growth but they are not known to have caused a high level of mortality.

Summer water quality at Bulkhead Cove was greatly improved with the installation of a one horse-power centrifugal pump in August 1997. This pump continuously moves higher quality lake water (25 gpm) 200 feet to the back of the cove. In addition, an electrical outlet was installed earlier in 1997 by the Bureau of Reclamation. These are used to power an aerator that continuously runs during the summer. Prior to the mechanical improvements, DO in August 1996 averaged 2.21 mg/L. After installation of the pump and aerator, DO increased to a mean of 10.73 mg/L in August 1997.

Growth

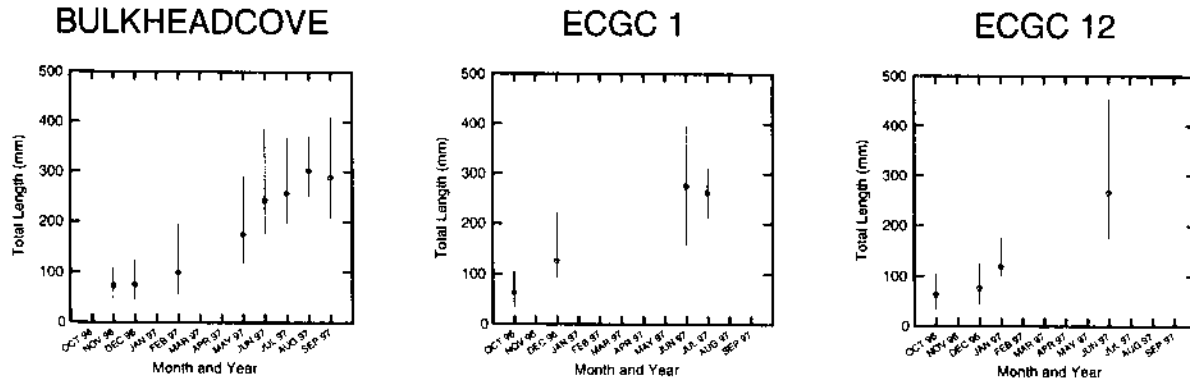
To increase growth rates and pond densities supplemental feeding was continued at Bulkhead Cove and implemented at Office Cove, ECGC 1, ECGC 12, and ECGC 18 Lower. To minimize labor we installed solar powered automatic feeders that hold approximately 80 pounds of commercial fish feed. Fish were fed continuously during the growout period at a rate of 3% body weight per day. Supplemental feeding also provides a alternate food source during the summer when naturally occurring food sources (e.g. macroinvertebrates and zooplankton) are scarce (Table 5, Appendices B,C,D, and E).

Bonytail chub, not stocked during the 1997 production period, were captured in Office Cove and Pond 1 at the Emerald Canyon Golf Course (Appendix K). Data are insufficient to graphically illustrate any relationships. Based on personal observations it appears that bonytail chub grew faster in 1997 than in 1996.

Razorbacks in Bulkhead Cove (Figure 5, Appendix K) grew 1.55 mm/mo from stocking in November 1996 to December, 11.78 mm/mo from December to February, 25.16 mm/mo from February to May, 68.12 mm from May to June. Due to the improvements to water quality they continued to grow 14.73 mm from June to July, and 44.45 mm from July to August.

Razorback suckers in ECGC 1 (Figure 5, Appendix K) grew an average of 31.09 mm/mo from October 1996 to December, 24.9 mm/mo from December to June, and 0.0 mm in July.

Figure 5. Monthly growth of razorback suckers in selected Lake Havasu Native Fish Management Program growout facilities during the 1997 production period. Vertical bars represent maximum and minimum total lengths. Circles are the means of the length data.



In ECGC 12, razorback suckers grew 75.14 mm/mo from October 1996 to December, 42.43 mm in December, and 25.0 mm/mo from January to June (Figure 5, Appendix K).

As in 1996, growth in ECGC 1 and ECGC 12 was highest in the spring with warmer water temperatures and adequate DO and slower during the winter due to lower water temperatures. During the summer, growth was essentially zero because of the higher water temperatures and low DO levels and, in part, to the cropping of fish greater than 250 mm TL.

Growth at Bulkhead Cove was also slow during the winter and greatest in the spring. Due to heavy cropping of fish greater than 250mm TL starting in May, the growth curve in Figure 5 shows growth slowing during the summer when it most likely increased with the decrease in fish biomass.

1998 PRODUCTION PERIOD

In 1998 the LHNFP plans to continue growing-out razorback suckers and bonytail chub in Bulkhead Cove, Office Cove, ECGC Ponds, and the High Levee Pond. Planned improvements to production include the installation of a pump to introduce lake water into at Office Cove to help alleviate marginal summer water quality. Also, the BLM has received a grant from the Central Utah Project to install a supplemental aeration system at ECGC Pond 12. All fish will continued to be fed using solar powered automatic feeders.

AGFD has committed to provide our program several thousand large razorback suckers from Bubbling Ponds in 1998. On February 20, 1998 they released into Lake Havasu at Mesquite Bay 858 large razorback suckers. They plan to continue to rear razorback suckers until the program's objective is reached.

The BLM will continue support and provide funding for equipment, materials and labor for renovation and operation of Achii Hanyo. On November 3, 1997, 4,396 razorback suckers were stocked at this facility. We anticipate that production of razorback suckers at this facility should exceed 2,000 individuals. They will be stocked in the fall of 1998. Bonytail chub are planned to be stocked in March of 1998 which will make them large enough to be released into Lake Havasu in late fall 1998 or early winter 1999. The first years production will probably be less than 50%. The inherent "bugs" that will inevitably have to be worked out will occur. The production potential of this facility is tremendous but will come only with a commitment of reaching our objective from all project partners.

LAKE HAVASU NATIVE FISH CAPTURES AND SIGHTINGS

In past two years two bonytail chub and eight razorback suckers reared in growout facilities or hatcheries have been captured in Lake Havasu (Table 8). These captures document survival, albeit they were captured after being at liberty for only one to four months. The small number of bonytails and razorbacks captured may be correlated to the limited effort put forth and to the relatively small population of these species in the lake. Capture locations suggest an affinity to the Bill Williams River arm of Lake Havasu, however, other factors such as amount and location of capture effort, time at liberty, and other factors probably influence these results.

The FWS was unable to locate the passive integrated transponder (PIT) tag in one razorback sucker captured from the Bill Williams River delta. We believe this fish to have been improperly tagged or had lost its tag after release, and is a cove fish. One razorback sucker was sighted by a SCUBA diver in Mesquite Bay located at the north end of the lake on September 22, 1996. This fish could have been one that was released a few days earlier at Campbell Cove, approximately two miles south of Mesquite Bay. Another razorback sucker was caught in April 1997 by an angler from Whipple Bay located near the center of the lake using anchovies for bait. The fish was reportedly released alive back into the lake. Both the angler and SCUBA diver gave excellent descriptions of these fish and we believe these accounts to be accurate.

The two bonytail chub and five razorback suckers were captured by the FWS in the Bill Williams River delta had been PIT tagged and are therefore known to have been released at Office Cove, approximately one mile from their capture location. AGFD captured two razorback suckers in 1997. One PIT tagged individual was captured from Question Mark Cove on the Bill Williams River arm of Lake Havasu and was released near Parker Dam. This fish had been at liberty for four months and was captured about four miles from its release point. The other razorback sucker captured by AGFD was taken from Wren Cove

approximately three miles south of Lake Havasu City. They were unable to locate a PIT tag, however, this fish is most likely from a release of coded wire tagged razorbacks on November 5, 1997 at Havasu Marina in Lake Havasu City.

Table 8. Account of razorback suckers and bonytail chub captured or sighted from Lake Havasu.

PIT Tag Number	Location	Capture Date	Total Length at Capture (mm)	Release Location	Release Date	Total Length at Release (mm)	Observers
Bonytail Chub							
200A192F0E	Bill Williams River Delta	01 Feb 96	334.0	Office Cove	25 Jan 96	336.0	FWS
2001322E7F	Bill Williams River Delta	01 Feb 96	287.0	Office Cove	01 Dec 95	286.0	FWS
Razorback Sucker							
1F520A7213	Bill Williams River Delta	10 Jul 96	268.0	Office Cove	09 Jul 96	268.0	FWS
40377F0826	Bill Williams River Delta	11 Jul 96	323.0	Office Cove	13 Jun 96	291.0	FWS
4038094C71	Bill Williams River Delta	18 Mar 96	269.0	Office Cove	08 Feb 96	267.0	FWS
1F62586047	Bill Williams River Delta	27 Feb 96	310.0	Office Cove	06 Nov 95	256.0	FWS
None Located ¹	Bill Williams River Delta	27 Feb 96	343.0	Unknown	Unknown	Unknown	FWS
Not Scanned	Mesquite Bay	22 Sep 96	350.0 (estimated)	Unknown	Unknown	Unknown	SCUBA Diver
None Located ²	Wren Cove	19 Nov 97	313.0	Unknown	05 Nov 97	Not Recorded	AGFD
407F671F3D	Question Mark Cove	22 Oct 97	409.0	Bulkhead Cove	01 Jul 97	257.0	AGFD
Not Scanned	Whipple Bay	April 97	325.0 (estimated)	Unknown	Unknown	Unknown	Angler

¹ This fish was scanned but no tag found. It was PIT tagged (#2001765316) at day of capture, 27 Feb 96.

² This fish was scanned but no tag found. It was PIT tagged (#010525568) at day of capture, 19 Nov 97.

SUMMARY

To date we have achieved 7.9% of our objective for razorback suckers and 1.0% for bonytail chub and are far from attaining our objective. With five years left in our program it is apparent that the lower Colorado River growout facilities currently in use must be managed intensively to maximize harvest. In addition, constructed rearing ponds capable of producing several thousand fish per year must also be utilized. Project partners have and will continue to improve environmental conditions in existing growout facilities, continue rearing fish at aquaculture facilities, and pursue and develop additional off-lake rearing space in order to produce large numbers of releasable length fish.

The commitment by the AGFD and the FWS to produce large numbers of razorback suckers for the LHNFP, at Bubbling Ponds and Achii Hanyo, respectively, will ensure that we meet our objective. Bonytail chub production is less certain but considering the large number of these fish that can potentially be reared at Achii Hanyo we are optimistic that our objective of augmenting 30,000 of these individuals into Lake Havasu will occur in less than five years.

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